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Refereed paper

Presentation of body mass index within an electronic health record to improve weight assessment and counselling in children and adolescents

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ABSTRACT

Background Assessment of weight and counselling on nutrition and physical activity is infrequently conducted during well child visits, despite recent expert recommendations.

Objective We investigated whether automatic calculation of body mass index (BMI) in an electronic health record improved assessment of weight and counselling on nutrition and physical activity.

Methods Retrospective review of well child visit records of children between two and 18 years of age (n=550) before and after implementation of an electronic health record system at an academic medical centre's paediatric clinic. Body mass index was automatically calculated and presented within the electronic health record. We measured clinicians' documentation of assessment of weight status, and assessment of and counselling for nutrition and physical activity risk factors.

Results Documentation of assessment of BMI and weight status did not increase. There were no consistent increases in assessment for or counselling on specific nutrition and physical activity behaviours, except with respect to high calorie food intake. Although overall assessment of physical activity decreased, physical activity counselling significantly increased. Documentation of the presence of high-risk family history increased significantly; the provision of counselling for high-risk family history did not show any corresponding increase. Patients with higher BMI percentile scores were more completely assessed for weight status. Completeness of weight status assessment was associated with increased counselling for nutrition and physical activity.

Conclusions Passive changes, such as automatic calculation of BMI, are insufficient to result in systematic improvements in assessment of weight and counselling for nutrition and physical activity.

Keywords: adolescent, assessment, body mass index, child, computerised medical record system, counselling, diagnosis, documentation, medical records, obesity, overweight, paediatrics, primary health care, quality of health care

Clinical relevance of body mass index (BMI) in children

- Experts in the USA recommend that clinicians calculate and track children's body mass index (BMI) at all primary care visits.[1]
- For children and adolescents between two and 19 years of age, BMI-for-age is a better predictor of overweight and obesity when compared with weight-for-height.[2]
- Assessing BMI percentile in children helps clinicians evaluate growth trajectory better than if solely height or weight were used.[3] Assessment of BMI is associated with higher rates of diet and activity counselling.[4–7]
- For the purpose of this study, we used standardised growth charts for BMI published by the Centers for Disease Control and Prevention using data from children in the USA. We utilised the Institute of Medicine's definitions of overweight and obesity.[1,3,8]
- Cut-off points for BMI in children, based on international growth studies in six countries (namely, Brazil, Great Britain, Hong Kong, the Netherlands, Singapore and the USA) are available. The goal of these cut-off points is to develop more internationally-based definitions of childhood overweight and obesity.[9]

Where this study fits in

- Assessment of weight and counselling on nutrition and physical activity is infrequently conducted during primary care paediatric visits, despite expert recommendations.
- Younger children and children with lower severity of obesity are less likely to be assessed using BMI.
- Passive changes, such as automatic calculation of BMI, are insufficient to result in systematic improvements in the assessment, prevention and management of paediatric obesity.
- A multifaceted intervention that simultaneously targets different barriers to change is likely to be more effective than a single intervention.
- An active alert that requires the clinician to respond to an abnormal BMI value may be more effective in enhancing the assessment of weight status than the passive alert displayed as part of our intervention.

Introduction

Approximately 93% of children in the USA have a specific source of primary care.[10,11] Expert recommendations in the USA regarding the prevention, assessment and treatment of paediatric overweight and obesity advise that clinicians calculate and track body mass index (BMI) and offer counselling on diet and physical activity at all primary care visits.[1]

Formulating clinical guidelines is necessary, but not sufficient, to improve primary care.[12] Clinicians use visual inspection as the most common method for assessing excess weight, which may lead to underdiagnosis of children who are overweight.[6,7,13] Only 11–19% of paediatric healthcare providers report using BMI routinely during primary care.[13,14] Medical record reviews show that only 6% of all children and 20–53% of overweight children have their weight status documented.[5–7,15,16] Younger children and those with lower severity of obesity are less likely to be screened using BMI.[5,6,16] Obesity prevention counselling is conducted in only between 17 and 25% of well child visits.[6,17]

Electronic health records (EHRs) may be related to improved quality,[18–21] fewer medical errors,[22–24] enhanced financial performance[25,26] and increased physician satisfaction in primary care.[27,28] Use of EHRs has been shown to improve documentation and treatment of obese adult patients.[29] The 'Precede/Proceed' planning model can help identify intervention strategies to address factors that influence clinicians' behaviour with respect to assessment and counselling.[30] Applying this model, automatic calculation and presentation of BMI within EHRs may serve as an enabling factor by reducing the time, effort and training needed to calculate BMI as well as serving as a cue to initiate discussion of diet, physical activity and weight. Our objective was to determine whether automatic calculation of BMI in an EHR improved clinicians' documentation of paediatric weight assessment and counselling in a primary care clinic. Our hypothesis was that documentation of obesity assessment and counselling would increase following implementation of EHRs. To our knowledge, this is the first study that investigates whether presentation of an automatically calculated BMI within an EHR improves documentation of paediatric weight assessment and counselling.

Methods

Setting

This study was conducted at a primary care paediatric clinic in Sacramento County affiliated with an academic children's hospital. During this two-year study, there were 48 paediatric residents and 12 attending clinicians (ten physicians and two nurse practitioners) who saw patients for well child visits. All patients seen by residents were examined by the resident and reassessed by an attending physician. To reduce the effect of temporal trends due to graduation of third year residents and admission of new first year residents into the programme, data were collected during the same six-month period of the year (from 1 January to 30 June) during the two consecutive years of the study.

Participants

The study was approved by the University of California Davis Medical Center Institutional Review Board. Patients between two and 18 years of age seen for well child visits between 1 January and 30 June 2006 (pre-EHR implementation period) and between 1 January and 30 June 2007 (post-EHR implementation period) were included. Patients who were wheelchair bound or had cerebral palsy were excluded from the study since accurate height measurements of such patients might have been difficult to obtain. Two patients were excluded for these reasons, both in the pre-EHR time period. We documented if subjects had chronic medical conditions which might draw attention to weight, such as very low birth weight, prematurity, genetic syndromes, congenital heart disease, cystic fibrosis, diabetes mellitus, gastrointestinal resection, malabsorption, malnutrition or developmental delay.

Intervention

EHRs were implemented in November 2006.[31] When patients' weight and height are entered into the EHR, BMI is automatically calculated and is displayed along with the other vital signs. Since the EHR system calculates BMI in the operating document, the BMI value is not retained in the vital signs section for reference at a future encounter, unless clinicians add it to their visit notes. The BMI is additionally plotted by the EHR system on age- and sex-specific Centers for Disease Control and Prevention 2000 growth charts, and this plot is retained within the patient's records.[8] At the time of implementation of this EHR system at our institution, neither BMI percentile values nor BMI z-scores were automatically presented. All clinicians received training consisting of demonstration and practice prior to EHR implementation.

Data collection

We conducted a retrospective review of consecutive patient charts before and after the implementation of the EHR. The principal investigator and the chart reviewer, a third year paediatric resident, reviewed 20% of patient charts together until they were in consistent agreement with respect to assessment of outcome measures. Before data collection commenced, the investigators specified that a minimum clinically significant difference in BMI documentation and counselling behaviours would correspond to 15 percentage points for binary outcomes, or 0.30 units of standard deviation for other outcomes (e.g. scale scores). To have 80% power to detect minimum clinically significant differences in mean levels of the outcome between the two study periods under two-sided testing with a type-1 error probability (alpha) of 5%, an effective sample size of 368 patients would be required. In anticipation that variance inflation arising, in particular, from non-response and from the nesting of patient visits within physicians (i.e. clustered data design effects) might approach 50%, we planned to review a total actual sample size of 550 visits in order to ensure that we would achieve the required effective sample size.[32,33]

A total of 550 patient charts were reviewed, 274 prior to the implementation of EHRs and 276 following the implementation of EHRs. Well child visits are recommended at 24 and 30 months of age, followed by yearly well child visits from three to 18 years of age.[34] Therefore we assumed that each patient included in the study had only one well child visit in each six-month period of data collection.

Outcome measures

The primary outcome measures in the 550 charts reviewed were binary indicators for the accurate documentation of BMI, BMI percentile and weight status category (underweight, normal weight, overweight or obese) respectively, in the physical exam, assessment or plan sections of the visit chart. Secondary outcomes were clinicians' documentation of assessment of, and counselling for, specific behaviours and risk factors related to nutrition, physical activity, weight or high risk family history (e.g. obesity, type 2 diabetes, dyslipidaemia or hypertension).

To measure the overall completeness of weight assessment documentation, a summary scale score was computed by adding together the three binary indicators for accurate documentation of BMI, BMI percentile and weight status. Scales summarising the completeness of nutrition assessment and of nutrition counselling were similarly computed, by adding together the nine binary indicators for the assessment of and counselling for, respectively, the specific nutrition factors. Similarly, summary scales for physical activity assessment and counselling were computed, based on the five physical activity items. For purposes of computing summary scale scores, missing values on individual items were replaced with the mean value of the patient's non-missing values for the other items comprising the scale, unless fewer than half of those items had values, in which case the patient was given a missing value for the summary scale.

Data analysis

Statistical analysis was carried out using Version 9.2 of the SAS System[35] and aimed to characterise and compare the sample at pre- and post-EHR time points on patient and provider characteristics as well as on primary and secondary outcomes. To account for clustering of patient visits within physicians, survey data analysis methods for clustered samples were used. Statistical significance was assessed using two-sided testing with alpha equalling 5%. For comparisons of continuous measures between time points, cluster adjusted *T*-tests were used to compare mean values and were computed using PROC SURVEYREG. For assessing whether categorical measures were associated with the study time point, we used standard contingency table methods, as follows: when all marginal totals were ten or greater, we used the adjusted Wald log-linear *F* statistic and associated *P*-values available from PROC SURVEYFREQ; when a marginal total was less than ten, raising concerns that the approximate *P*-values from other contingency table methods might be grossly inaccurate (owing to poor asymptotic approximations of the reference sampling distribution), we used the Fisher Exact Test available from PROC FREQ.

The survey data analysis regression procedure PROC SURVEYREG was also used to estimate multiple regression models and test statistics that were used to assess whether the completeness of weight assessments and counselling varied according to patient or provider characteristics and whether they changed over time.

Results

A total of 550 patient charts were reviewed, 274 before and 276 after implementation of the EHR. Sixty clinicians provided care at these visits. Patient and clinician characteristics were similarly distributed at both time points (Table 1). The mean ($\pm$ SE) of patients was seven ($\pm$ 0.3) years and approximately one-third had private insurance cover. Approximately 4% of patients were underweight, 19% overweight and 21% obese.

BMI screening before and after EHR implementation

There were no statistically significant changes in any of the three primary outcome measures used to assess BMI screening in well child visits (Table 2). Accurate documentation of BMI was present in 17% of pre-EHR visits and in 3% of post-EHR visits; accurate documentation of BMI percentile occurred in 13% of pre-EHR visits and 4% of post-EHR visits (P=0.15). Accurate documentation of weight category occurred in 14% and 12% of pre- and post-EHR visits respectively (P=0.32). While before EHR implementation 16% of visits had BMI percentile plotted on growth charts, all visits had BMI percentile plotted following EHR implementation (P<0.001).[8] Documentation of other less specific references to body weight declined significantly, from 68% to 54% (P=0.04). Approximately 28% of pre-EHR visits and 16% of post-EHR visits had at least one weight-related element documented (any one of the following: BMI, BMI percentile, weight category or weight trajectory; P=0.14).

Nutritional assessment and counselling

Documentation of assessment of high calorie food intake increased from 8% to 13% (P=0.048), and documentation of counselling with respect to this behaviour increased from 3% to 24% (P<0.001). Assessment and counselling with respect to other nutrition behaviours measured was similar at both time points (Table 3).

Physical activity assessment and counselling

Assessment of physical activity (Table 4) declined after EHR implementation from 8% to 4% (P=0.02); however, counselling on physical activity increased from 9% to 32% (P<0.001). There was no statistically significant difference between the two time periods in assessment and counselling regarding screen time and the presence of a television in the child's bedroom.

Family history and readiness to change assessment and counselling

Documentation of assessment of high risk family history significantly increased from 7% to 62% following EHR implementation (P<0.001). Despite this increase in assessment, counselling for such history was documented in only 1% of visits in both time periods.

Table 1 Sample characteristics before and after EHR implementation, *n* (%) (*n*=550)

	Before EHR (*n*=274) *n* (%)	After EHR (*n*=276) *n* (%)	*P*-value†
Gender			0.93
Male	134 (48.9)	136 (49.3)	
Female	140 (51.1)	140 (50.7)	
Age (yrs): mean(SE)	7.09 (0.39)	6.80 (0.34)	0.32
Health insurance status			0.96
Private	92 (33.6)	92 (33.3)	
Public/uninsured	182 (66.4)	184 (66.7)	
Type of clinician seen at visit			0.96
PL1	31 (11.3)	29 (10.5)	
PL2	34 (12.4)	44 (15.9)	
PL3	70 (25.5)	61 (22.1)	
Faculty physician only	89 (32.5)	94 (34.1)	
Nurse practitioner	50 (18.2)	48 (17.0)	
Weight status			0.45
Underweight	8 (2.9)	13 (4.7)	
Healthy weight	157 (57.3)	148 (53.6)	
Overweight	53 (19.3)	51 (18.5)	
Obese	55 (20.1)	59 (21.4)	
Unknown	1 (0.36)	5 (1.81)	

† Two-sided *P*-values based on test statistics adjusted for clustering at the provider level

Table 2 BMI screening before and after EHR implementation, *n* (%) (*n*=550)

	Before EHR (*n*=274)	After EHR (*n*=276)	*P*-value†
Weight documented	273 (99.6)	276 (100.0)	0.50‡
Height documented	274 (100)	272 (98.6)	0.12‡
BMI documented accurately	46 (16.8)	9 (3.3)	0.09
BMI percentile plotted accurately	45 (16.4)	214 (100)	<0.001*
BMI percentile documented accurately	36 (13.1)	11 (4.0)	0.15
Weight category documented accurately	39 (14.2)	32 (11.6)	0.32
Any other reference to weight documented	158 (67.8)	130 (53.7)	0.03*
Weight trajectory documented	1 (0.4)	7 (2.5)	0.07‡
Documentation of at least one element from BMI, BMI percentile, weight category or trajectory	77 (28.1)	45 (16.3)	0.14
Presence of chronic medical condition that could draw attention to weight	17 (6.2)	17 (6.2)	0.98

† Two-sided *P*-values. Unless specified otherwise, *P*-values based on test statistics adjusted for clustering at the provider level
‡ Fisher's exact test for independent data was used because of small marginal row totals
* Statistically significant at alpha=0.05 (two-sided test)

Table 3 Documentation of nutrition assessment and counselling before and after EHR implementation, *n* (%) (*n*=550)

	Before EHR (*n*=274)	After EHR (*n*=276)	*P*-value†
Portion size			
Assessed	3 (1.1)	1 (0.4)	0.37‡
Risk factor documented	2 (0.7)	0 (0.0)	0.25‡
Counselling documented	1 (0.4)	0 (0.0)	0.50‡
Fruit and vegetable intake			
Assessed	88 (32.1)	75 (27.2)	0.31
Risk factor documented	19 (6.9)	33 (12.0)	0.07
Counselling documented	4 (1.5)	4 (1.4)	1.0‡
Sweetened drinks/sodas/juice intake			
Assessed	51 (18.6)	46 (16.7)	0.58
Risk factor documented	41 (15.0)	39 (14.1)	0.79
Counselling documented	13 (4.7)	2 (0.7)	0.00‡*
Fast food/outside food intake			
Assessed	19 (6.9)	17 (6.2)	0.74
Risk factor documented	10 (3.6)	14 (5.1)	0.43
Counselling documented	1 (0.4)	0 (0.0)	0.50‡
High calorie food intake			
Assessed	21 (7.7)	36 (13.0)	0.048*
Risk factor documented	15 (5.5)	31 (11.2)	0.02*
Counselling documented	7 (2.6)	66 (23.9)	<0.001*
Eating/meal/snacking pattern			
Assessed	8 (2.9)	7 (2.5)	0.79
Risk factor documented	6 (2.2)	3 (1.1)	0.34‡
Counselling documented	3 (1.1)	3 (1.1)	1.0‡
Breakfast intake			
Assessed	4 (1.5)	5 (1.8)	1.0‡
Risk factor documented	2 (0.7)	3 (1.1)	1.0‡
Counselling documented	1 (0.4)	2 (0.7)	1.0‡
Family meals			
Assessed	1 (0.4)	0 (0.0)	0.50‡
Risk factor documented	0 (0.0)	0 (0.0)	–
Counselling documented	0 (0.0)	0 (0.0)	–
Other reference to nutrition			
Assessed	242 (88.3)	251 (90.9)	0.45
Risk factor documented	73 (26.6)	84 (30.4)	0.31
Counselling documented	103 (38.3)	191 (69.2)	<0.001*

† Two-sided *P*-values. Unless specified otherwise, *P*-values based on test statistics adjusted for clustering at the provider level
‡ Fisher's exact test for independent data was used because of small marginal row totals
* Statistically significant at alpha = 0.05

Table 4 Documentation of physical activity assessment and counselling before and after EHR implementation, *n* (%); (*n*=544)

	Before EHR (*n*=270)	After EHR (*n*=274)	*p*-value†
Physical activity			
Assessed	22 (8.1)	11 (4.0)	0.02*
Risk factor documented	2 (0.7)	5 (1.8)	0.45‡
Counselling documented	24 (8.9)	89 (32.5)	<0.001*
Screen time (TV, video, video games, computer)			
Assessed	19 (7.0)	16 (5.8)	0.57
Risk factor documented	13 (4.8)	11 (4.0)	0.57
Counselling documented	140 (51.9)	159 (58.0)	0.34
TV in bedroom			
Assessed	2 (0.7)	0 (0.0)	0.25‡
Risk factor documented	2 (0.7)	0 (0.0)	0.25‡
Counselling documented	1 (0.4)	0 (0.0)	0.50‡
Computer in bedroom			
Assessed	0 (0.0)	0 (0.0)	–
Risk factor documented	0 (0.0)	0 (0.0)	–
Counselling documented	0 (0.0)	0 (0.0)	–
Any other reference to physical activity			
Assessed	0 (0.0)	0 (0.0)	–
Risk factor documented	0 (0.0)	0 (0.0)	–
Counselling documented	0 (0.0)	0 (0.0)	–

† Two-sided *P*-values. Unless specified otherwise, *P*-values based on test statistics adjusted for clustering at the provider level
* Statistically significant at alpha=0.05
‡ Fisher's exact test for independent data was used because of small marginal row totals

Assessment of readiness to change with respect to lifestyle behaviour or weight was not documented at any visit.

Multiple regression analyses

Introduction of the EHR was not associated with statistically significant changes in weight assessment documentation after adjusting for patient and provider characteristics. Older patients ($P<0.001$) and patients with higher BMI percentile scores ($P<0.001$) had more complete documentation of weight assessment. Visits to faculty physicians contained more complete documentation of weight status compared with visits to nurse practitioners ($P=0.007$). Visits during which weight was assessed as well as those in which care was provided by a nurse practitioner had greater documentation of counselling for nutrition and physical activity.

Discussion

We conducted a review of medical records of well child visits to an academic medical centre paediatric clinic to determine whether automatic calculation of BMI in an EHR system improved clinicians' documentation of weight assessment and diet and nutrition counselling. The main findings of this research are that addition of automatic BMI calculation to an EHR did not improve clinicians' documentation of BMI, BMI percentile and weight category in their visit notes. Additionally, we did not find consistent increases in documentation of counselling on nutrition, physical activity and sedentary activity following EHR implementation. Younger children and children with lower severity of obesity were less likely to be assessed using BMI, both at the pre- and post-EHR time points.

In a survey conducted by Barlow *et al*, 19% of paediatric clinicians reported using BMI 'most of the time' or 'often', one-third reported never using BMI and 12% reported using BMI percentile during well child visits.[14] Objective assessments of BMI screening from medical record reviews show an even lower prevalence, with only 0.05% to 1% of children having BMI documented.[6] Similar to our findings, younger children and children with lower severity of obesity were less likely to be screened using BMI, suggesting that clinicians rely more on visual diagnosis than on BMI assessment to diagnose obesity, especially in younger children.[5,6,16] Paediatric obesity prevention counselling is conducted in only 17% to 25% of well child visits.[6,17] Our study similarly finds an overall low prevalence of BMI screening and obesity prevention counselling. One exception was that we noted a relatively high prevalence of counselling for screen time; approximately half of the visit notes in our study contained documentation of such counselling.

Linder *et al* studied the association between EHR use and 17 outpatient quality indicators, utilising data from the 2003 to 2004 National Ambulatory Medical Care Survey. For quality indicators related to the management of common diseases, preventive counselling and screening tests, there was no significant difference in performance between visits with and without EHR use. The authors concluded that as currently implemented EHRs were not associated with improvements in the quality of outpatient care.[36] Crosson *et al* found that practices using EHRs were less likely to attain measures for diabetes quality of care than practices without EHRs. The investigators concluded that this finding might be attributed to the degree to which clinicians used their EHR and resources accessible to support diabetes care.[37] To our knowledge, ours is the first study that investigates the effect of BMI calculation within an EHR on documentation of assessment and counselling for nutrition, physical activity and weight in children. As in the studies above, we found that, as currently implemented, EHRs at our institution were not associated with improvements in assessment and counselling for risk factors related to paediatric overweight and obesity.

Schriefer *et al* demonstrated that a computerised BMI prompt in the medical record increased the diagnosis of obesity and referral for treatment in obese adults seen by family physicians to some extent. Approximately 10% of patients seen by physicians in the control group diagnosed obesity in obese patients, as opposed to 16% in the experimental group.[38] Bordowitz *et al* conducted a similar study to determine if calculation of BMI in an EHR improved clinician documentation and treatment of overweight and obesity in adults.[29] The study found that although treatment of obesity increased after EHR implementation, treatment of overweight patients did not increase significantly. In our study, documentation of weight assessment did not improve following EHR implementation in patients with overweight and obesity. No increase in counselling for most lifestyle risk factors, except for high calorie food intake, increased in patients who were overweight and obese. Therefore, our findings indicate that passive changes, such as automatic calculation of BMI, are insufficient to result in systematic improvements in the assessment, prevention and management of paediatric obesity. A multifaceted intervention that simultaneously targets different barriers to change is likely to be more effective than a single intervention such as ours.[39] Additionally, an active alert that requires the clinician to respond to an abnormal BMI value may be more effective in enhancing the assessment of weight status in overweight or obese patients than the passive alert displayed as part of our intervention.[40]

Our study is retrospective and observational, and therefore has several limitations. First, our data describe the prevalence of assessment of weight status and counselling for nutrition and physical activity at two time points, before and after implementation of EHRs. Due to limitation of this study design, a causal relationship between the implementation of EHRs and changes in the prevalence of assessment and counselling cannot be proven. Second, non-documentation of the BMI by the clinician does not necessarily mean that the automatically calculated BMI was not discussed at the visit. Third, we were unable to determine clinicians' workflow during the patient encounter, for example whether clinicians accessed the vital signs section of the EHR while they were face to face with the patient. EHR systems at other institutions may be designed to present and document BMI and counselling for diet and physical activity differently from the system at our institution, which may present issues regarding generalisability of our study setting. The decline in the documentation of less specific references to body weight may have occurred due to clinicians' assumption that BMI would be automatically incorporated into the visit documentation; however, we are unable to explain the decrease in documentation of assessment of physical activity after EHR implementation.

We conclude that automatic BMI in an EHR may be inadequate to improve weight assessment and diet and physical activity counselling. Based on this study we are implementing four strategies at our institution:

1 provide further education to clinicians regarding expert recommendations for obesity prevention
2 modify software to enable automatic calculation and retention of BMI, BMI percentile and weight category in the vital signs and progress notes sections of the EHR
3 include lifestyle assessment and counselling cues within structured encounter forms

4 incorporate system-initiated cues or alerts linked to expert recommendations if a patient's BMI is >85th percentile for age and sex.[41]

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CONFLICTS OF INTEREST

None.

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